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**Description**

**Arrangement Enabling a Liquid to Flow Evenly Around a Surface of a Sample and Use of Said Arrangement**

The invention relates to an arrangement enabling a liquid to flow evenly around a surface of a sample, with the sample rotating in said liquid. In addition thereto, the invention relates to the use of said arrangement.

Such arrangements are employed in particular for electro-processing surfaces, in which a sample connected to the cathode as well as an anode are arranged opposite each other in an electrolyte. It is desirable in electrodeposition in this regard that the deposited layers be homogeneous across the coated surface with respect to layer thickness and other functional properties, such as intrinsic stress. This necessitates a uniform transfer of the substance dissolved in the electrolyte to the layer surface.

The document EP 0 856 598 A1 discloses an apparatus for electroplating a surface, in which a rotating sample is laterally subjected to the flow of the electrolyte through a nozzle. Due to the rotating sample, a homogeneous layer thickness may be obtained by averaging. The disadvantage of this arrangement consists in that the flow discharged from the nozzle is not laminar. The thus caused formation of eddies results in non-uniform deposition rates. Furthermore, the non-uniform flow also affects the anode on which the material to be deposited dissolves in the electrolyte. With non-uniform flow to

the anode, there may occur ion concentration differences within the electrolyte.

Furthermore, there are arrangements known for electrodeposition of layers in which a sample at rest is arranged in a flow cell. With the flow cell, the flowing in and flowing out liquid is passed through a plurality of small tubes arranged in parallel. This arrangement thus attempts to create an as uniform as possible flow in the cell. The disadvantage of this arrangement consists in that particles present on the sample at rest may cause flow shadows. In addition thereto, partially occurring inhomogeneities in the electric field between anode and cathode are not compensated due to the sample at rest.

It is thus an object of the present invention to make available an arrangement enabling a uniform flow of a liquid around a surface of a sample in which flow eddies or turbulences, flow shadows and inhomogeneities due to a sample at rest are avoided and in which the flow across the surface is of laminar nature.

According to the invention, this object is met by an arrangement according to claim 1. Advantageous developments of the invention as well as uses of the invention are indicated in the further claims.

The invention indicates an arrangement enabling a liquid to flow evenly around a surface of a sample, comprising a flow chamber through which said liquid flows. In said flow chamber, a sample is provided at least in part and can be rotated about an axis of rotation by means of a rotary drive. Starting from an inflow container and an outflow container, inflow pipes and outflow pipes, respectively, extend from and to opposite ends of the flow chamber. The pipes start from the respective containers.

The liquid is supplied to the inflow container via an inflow tube. The liquid is discharged from the outflow container via an outflow tube beginning in the latter. The inflow and outflow containers just have a manifold function from the tubes to the pipes. The arrangement furthermore has means suitable for generating a flow. In addition thereto, the arrangement has filters through which said liquid flows at a location of said arrangement. These filters are arranged either in the inflow and outflow containers, respectively, or in the inflow and outflow pipes, respectively.

Due to the combination of a flow cell and a filter having the liquid flowing therethrough, according to the invention, and due to the homogeneous flow in the inflow and outflow pipes resulting therefrom, a laminar flow around the surface is obtained together with a rotating sample. The effect achieved furthermore is that inhomogeneities occurring due to a stationary sample are avoided.

A particularly homogeneous flow around the surface is obtained according to the invention in that the pores of the filter or filters are set such that, with respect to the size and number thereof, that the pressure differential between the inflow and outflow pipes, which have different distances from the inflow or outflow tube, is compensated. This is achieved preferably in that, in case of pipes further away from the inflow or outflow tube, a larger overall pore area of the associated filter or filter portion has liquid flowing therethrough as compared to pipes arranged close to the inflow or outflow tube.

The arrangement according to the invention may be used in particularly advantageous manner for electro-depositing or electro-removing material on or from the surface

of a sample if the flow chamber has an electrode arranged therein and the liquid is an electrolyte. The sample and the electrode are connected to a current source. It is possible to employ a dc current source the polarity of which is chosen in correspondence with the application for depositing or removing. The current source moreover may also be of pulsating nature, thereby permitting also the deposition of mechanically twisted layers on the sample surface.

Particularly advantageous is an arrangement for electrodepositing or electro-removing material on or from a surface of a sample, in which according to the invention the flow chamber has two mutually parallel planar confining walls. The confining walls have a first and a second recess, respectively. The sample has a substantially planar surface and is arranged to be rotatable about an axis of rotation perpendicular to said surface, such that this surface covers the first recess, with the surface defining a plane together with the associated confining wall. The electrode has a planar surface as well, covering the second surface and defining a plane with the associated confining wall. The flow chamber in this case is confined by planar confining walls extending parallel to the inflow and outflow pipes, which further encourages the formation of a laminar flow.

Particularly advantageous is an arrangement for electrodepositing material, in which according to the invention the anode is a grid basket of electrochemically inert material, which has a planar surface containing holes. This grid basket is filled with the material to be deposited, which is in granular form. Due to the granular form of the material to be deposited, the area of contact with the electrolyte is especially large, whereby the material to be deposited dissolves more easily in the electrolyte.

In addition thereto, it is especially advantageous if the electrode consists of a metal coated with platinum or another noble metal. In this case, material to be deposited will be re-furnished solely by substitution of the spent electrolyte. The electrolyte or the usually aqueous solvent thereof will then be decomposed at the anode. A possible electrochemical reaction with an electrolyte containing dissolved nickel would be, for example, the deposition of nickel on the cathode and the simultaneous generation of oxygen from the water of the solution at the anode.

Especially advantageous is an arrangement enabling a liquid to flow evenly around a surface of a sample, in which according to the invention the inflow and outflow tubes each extend via a throttle valve into a supply container filled with liquid. Suitable means for generating a flow in this regard is a liquid pump pumping the liquid of the supply container through the inflow tube. Furthermore, the supply container contains means for filtering and for regulating the temperature, the pH value and the filling level of the liquid. In the event that the liquid is an electrolyte, there are provided moreover means for regulating the ion concentration of the electrolyte.

It is thus rendered possible, for example, to control a coating process with very high accuracy, since monitoring and control of the relevant parameters of temperature, pH value and ion concentration of the electrolyte are favorable for homogeneous layer deposition.

The invention may be employed in particularly advantageous manner for depositing a mechanically twisted layer of a nickel/iron alloy on a wafer. This wafer then consists preferably of silicon or ceramics. The effect

achievable by use of the arrangement according to the invention is that the composition of the alloy and the intrinsic mechanical stress of the layer is homogeneous across the wafer. By patterning rectangles that are subsequently etched back in part, springs bent away from the wafer may be produced from the deposited layer in a batch process. Such springs are utilized, for example, in miniaturized relays.

The arrangement according to the invention may also be utilized in particularly advantageous manner for applying electrophoretic varnish or resist to wafers. The voltage required for electrophoresis is applied between the wafer and an opposing electrode.

Furthermore, the arrangement according to the invention may also be used very advantageously for electroless or autocatalytic deposition of material on the surface of the sample.

In addition thereto, the arrangement according to the invention may also be used for removing material from the surface of the sample with the aid of an etching solution. For example, the surface of a silicon wafer could be etched with KOH solution.

In the following, the invention will be elucidated in more detail by way of embodiments and the associated drawing figures.

Fig. 1 illustrates a schematic longitudinal sectional view of an arrangement according to the invention enabling a liquid to flow around a surface.

Fig. 2 illustrates a schematic transverse sectional view of a flow chamber of an arrangement enabling a liquid to

flow evenly around a surface, according to the invention.

Fig. 3 illustrates a schematic longitudinal sectional view of a supply container having an inflow tube and an outflow tube introduced therein.

Fig. 1 illustrates an arrangement enabling a uniform flow around a surface, comprising a flow chamber 1 having an electrolyte 2 provided therein. A wafer 3 is arranged on the upper side of the flow chamber 1. The wafer 3 is connected to a cathode 4 and rotatable about an axis perpendicular to its surface by means of a rotary drive 5. The rotary drive 5 is supported by means of bearing 22 and sealed with respect to the wafer with the aid of gasket 23. Arranged opposite the wafer 3 is a grid basket 15 connected to an anode 6 and containing the material to be deposited in the form of granulate 14. Flow chamber 1 is surrounded by a casing 18. Arranged laterally on each side of said flow chamber 1 are an inflow container 9 and an outflow container 10, respectively. Containers 9, 10 are connected to flow chamber 1 via inflow pipes 7 and outflow pipes 8, respectively. The inflow container 9 and the outflow container 10 each have a filter 13 arranged therein. This filter 13 provides for as uniform flow as possible through inflow pipes 7 and outflow pipes 8. The filter 13 has filter pores 24 allowing the electrolyte 2 to flow therethrough.

Fig. 2 shows a flow chamber 1 covered on the upper side by a wafer 3. Laterally of flow chamber 1, there are arranged an inflow container 9 and an outflow container 10. The inflow container 9 has an inflow tube 11 terminating therein which transports liquid into inflow container 9. The outflow container 10 has an outflow tube 12 beginning therein which transports liquid away from

outflow container 10. The flow chamber 1 is connected to inflow container 9 and outflow container 10 via parallel extending inflow pipes 7 and outflow pipes 8, respectively. Inflow container 9 and outflow container 10 have a filter 13 with filter pores 24 arranged therein. The size of the filter pores 24 is selected to vary across the overall filter area such that the pressure differential between inflow pipes 7 and outflow pipes arranged at different distances from the inflow tube 11 and the outflow tube 12, respectively, is compensated. This provides for uniform flow through the inflow pipes 7 and the outflow pipes 8, which favors a laminar flow in flow chamber 1.

Fig. 3 illustrates a supply container 17 filed with electrolyte 2 and having an outflow tube 12 and an inflow tube 11 extending thereinto. Inflow tube 11 is passed into supply container 17 via a throttle valve 16. Conveying pump 20 is used as means for generating a flow. Arranged in supply container 17 is a heater 19 used for regulating the temperature. By means of an additional conveying pump 25 and a filter cartridge 21, the electrolyte 2 from supply container 17 can be cleaned in a continuous process.

With the aid of the rotary drive and the conveying pump, the rotational speed of the wafer and the flow rate of the electrolyte can be matched to the desired process.

The invention is not restricted to the embodiments illustrated in exemplary form, but is defined in its most general form by claim 1.